CORONAL THERMAL STRUCTURE AND ABUNDANCE OF SUPER-METAL-RICH LATE-TYPE STARS

NASA Grant No. NAG5-9943

Final Report

For Period 15 September 2000 through 14 September 2002

Principal Investigator
Nancy Brickhouse

September 2002

Prepared for:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, MD 20771

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory
is a member of the
Harvard-Smithsonian Center for Astrophysics

This report covers the NASA grant NAG5-9943 for Cycle 1 XMM Guest Observer Program. The project is entitled ``Coronal Thermal Structure and Abundances of Super-Metal-Rich Late-Type Stars.'' The European P.I. is Antonio Maggio. This observation is for grating spectroscopy of 30 Ari, a late-type star with very high metallicity (about twice solar). The goal is to use extreme cases to help understand how abundances change from the photosphere to the corona.

The target was obtained by XMM-Newton on 2001 January 16 for 28000 sec. Data processing could not proceed until last fall because the SAS RGS software did not work. A poster was presented at the conference ``New Visions of the X-ray Universe in the XMM-Newton and Chandra Era,'' held in Noordwijk 26-30 November 2001. The paper was entitled, ``Coronal Abundances and Thermal Structure of the Super-Metal-Rich Star 30 Ari,'' by A. Maggio, F. Favata, N. S. Brickhouse, and A. K. Dupree. The poster presented analysis of EPIC and RGS data to determine the individual abundances from the star and the emission measure distribution as a function of temperature. Results were compared with previous results on this star by our team using ASCA data.

While the European members of the team provide the expertise on the analysis of XMM data and have led the analysis of the super-metal-rich stars, The U. S. team provides expertise on spectral modeling and the connections from the photosphere to the corona (via the chromosphere and transition region). N. S. Brickhouse is the team leader of the project to develop the Astrophysical Plasma Emission Code (now available publicly to the X-ray community) and is providing expertise on X-ray plasma diagnostics. A. K. Dupree is an expert on stellar atmospheres and modeling of ultraviolet through X-ray data.

The XMM observation was split into two segments, which could be co-added up because the source is almost constant. The target is a binary star (separation ~40 arcsec), well resolved in the EPIC images, although there is substantial overlap of the photon spatial distributions. Individual spectra for the two sources could be extracted, but their analysis will be difficult and has not yet been attempted. The EPIC data compare well with the ASCA results, where the two sources were not resolved. On the other hand, RGS1 and RGS2 spectra are available for the combined source only.

The ASCA best-fit model matches the EPIC/MOS1 and MOS2 spectra quite well, with no need for any renormalization (the source seems not to have changed over the long-term). The individual abundances are somewhat different than we derived from ASCA, but we are still investigating the accuracy (and reliability) of the new fitting results (they depend somewhat on the way the instrument response is computed). Even more problematic is the PN spectrum (no official instrument response has been available for observations in small window mode). Nevertheless, the MOS spectra already show that the additional component developed for the analysis of the ASCA Capella data (for high-n Fe XVII-XIX transitions, see Brickhouse et al. 2000, Ap J, 530,387) yields an almost perfect agreement between EPIC data and model in the range 9.4-10.8 A. The RGS spectra show a dozen bright lines, and what appears to be continuum emission. Using the emission measure distribution model, we can determine line-free regions to fit a continuum model, thus allowing us to get an estimate of the absolute Fe abundance, independently from the EPIC spectra. Possible density diagnostics from O VII (in RGS1 only) and from Ne IX (in RGS2 only) are being explored. These diagnostics have been shown to be difficult to analyze without an understanding of the continuum and weak line blending, as presented by Brickhouse at the Noordwijk conference.

The spectral analysis of 30 Ari is being prepared for submission to a refereed journal. A second target in this science program (Tau Boo) was recently accepted as a target in XMM Cycle 2. These data together will help us to determine if there are trends in the coronal abundances suggestive of the underlying photosphere.